Profile LFR-26

HLM EF

EUROPEAN UNION

GENERAL INFORMATION

NAME OF THE FACILITY	Heavy Liquid Metal Experimental Facility
ACRONYM	HLM EF
COOLANT(S) OF THE FACILITY	Molten lead or lead-bismuth eutectic
LOCATION (address):	European Commission, Joint Research Centre (JRC), Institute for Energy and Transport (IET), Westerduinweg 3, 1755 LE Petten, Netherlands
OPERATOR	JRC
CONTACT PERSON (name, address, institute, function, telephone, email):	European Commission, Joint Research Centre, Institute for Energy and Transport, Westerduinweg 3, 1755 LE Petten, Netherlands Tel.: +31 224 565 298 E-mail: kamil.tucek@ec.europa.eu
STATUS OF THE FACILITY	Under Construction
Start of operation (date):	2016

MAIN RESEARCH FIELD(S)

- ☐ Zero power facility for V&V and licensing purposes
- ☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
- ☐ Thermal-hydraulics
- ☐ Coolant chemistry
- ☒ Materials
- ☐ Systems and components
- ☒ Instrumentation & ISI&R

TECHNICAL DESCRIPTION

Description of the facility

The facility will allow conducting pre-normative, separate effect tests of candidate structural materials for HLM-cooled fast reactors inside realistic HLM environments in temperatures up to 650°C. The facility is design to study stress corrosion cracking / liquid metal embrittlement phenomena under tensile and compressive stress, and perform slow strain-rate tensile, fatigue, and fracture toughness tests with well-controllable parameters, in particular temperature, oxygen content in HLM, load, and fluid flow conditions. Tests of the reliability of HLM chemistry control systems as well as related components, including instrumentation, will also be possible.

The facility consists of two cylindrical tanks, measuring tank and dump tank, and connecting piping to transport HLM between the tanks as well as to deliver and extract gases to and from

the facility, respectively. The external diameter of measuring tank is 400 mm while internal diameter is 380 mm. The external and internal heights of the tank are 292 mm and 250 mm, respectively. The scheme of the facility and its 3D drawing are displayed in Figures below.

The main characteristics of the facility are:

- Designed to use lead as well as lead-bismuth eutectic;
- Working temperatures in HLM: up to 650°C;
- Working range of oxygen concentrations in HLM: 10^{-5} – 2 weight ppm (1 ppb – 200 ppm weight %) / saturation conditions;
- No. of test sections: 4;
- Reserve ports (diameter 30 mm) with multiple feed-throughs: 2;
- Design pressure: 0.5 MPa;
- Operating pressure: 0.2 MPa;
- HLM inventory: ca. 25 l;
- Structural material: AISI 316 Ti;
- Surfaces in contact with molten HLM are protected by aluminium coating using pack cementation technology;
- Active control of gas injected to cover gas space and to HLM (below surface);
- Online sampling of HLM composition during operation of the facility; and
- Gas and HLM filtering capability (cold traps).

Pressurized heavy gas – Ar – is used to flush the facility, to transport HLM and regulate its content in and flow through different parts of the facility. The oxygen and hydrogen control is achieved by gas mixture of Ar, Ar-4%H_2, and air.

Heaters are placed in sections around the tanks and pipes, each with its own power regulator. The heaters are operated automatically as well as manually, allowing melting, heat up, maintenance of temperatures, shutdown of the facility, and passive drainage of HLM to the dump tank. The degree of the HLM natural convection flow in the measuring tank is possible to regulate through the variation of power of external heaters and heat losses to an internal cooling channel. This feature facilitates a time-efficient control and adjustment of oxygen content in HLM, in addition to oxygen diffusion process from the cover gas space. Alternatively, gases can also be injected directly to HLM in both measuring and dump tanks.

The tests sections will allow measurements with the following characteristics:

- Specimens:
  - round bar tension;
  - compact tension, C(T), and disc-shaped compact tension, DC(T);
  - three- and four-point bending test;
  - segmented cone mandrel test.
- Maximum pressure in the test sections: 15 MPa of air for pneumatic-bellows-based loading system;
- Maximum load: 12 kN;
- Maximum displacement: 5 mm;
- Displacement rates: 10^{-8} to 10^{-2} mm/s;
- Strain rates: 10^{-7} to 10^{-2} s^{-1};
- Fatigue: maximum 0.1 Hz;
- Range of amplitudes: 0.1 to 0.0005 Hz;
- Test/hold times: at least 100 s up to 5,000 h.

The installed components and instrumentation include:

- Oxygen sensors in gas and in HLM to control the amount of oxygen dissolved in HLM;
- Thermocouples in gas and HLM;
- HLM weighting tensometric sensors to measure HLM level in the tanks;
- Pressure transducers;
- Overpressure protection through gas relief valves;
- Windows on the tank lids to control the surface of HLM and state of the cold traps.

Acceptance of radioactive material
No

Scheme/diagram

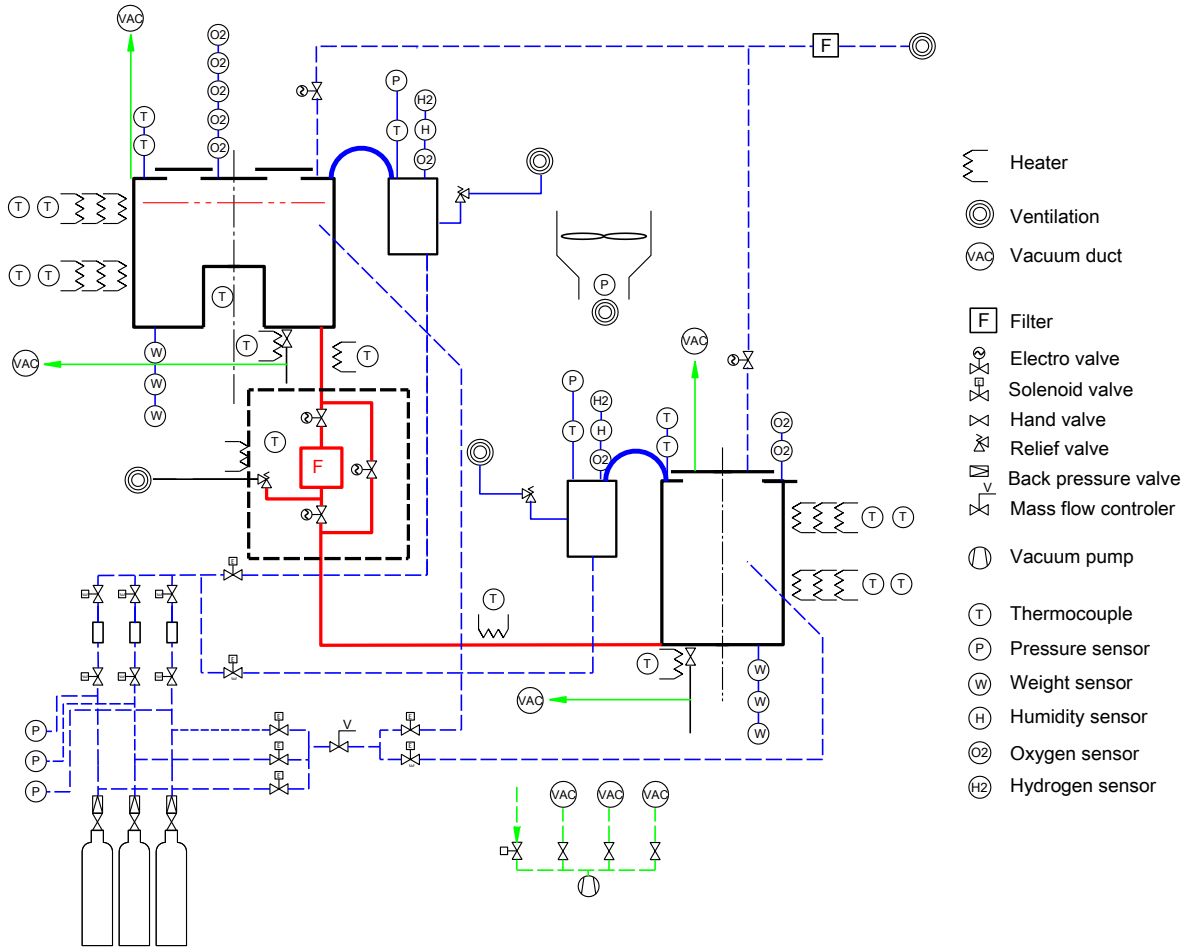

FIG. 1. Scheme of the Heavy Liquid Metal Experimental Facility

3D drawing

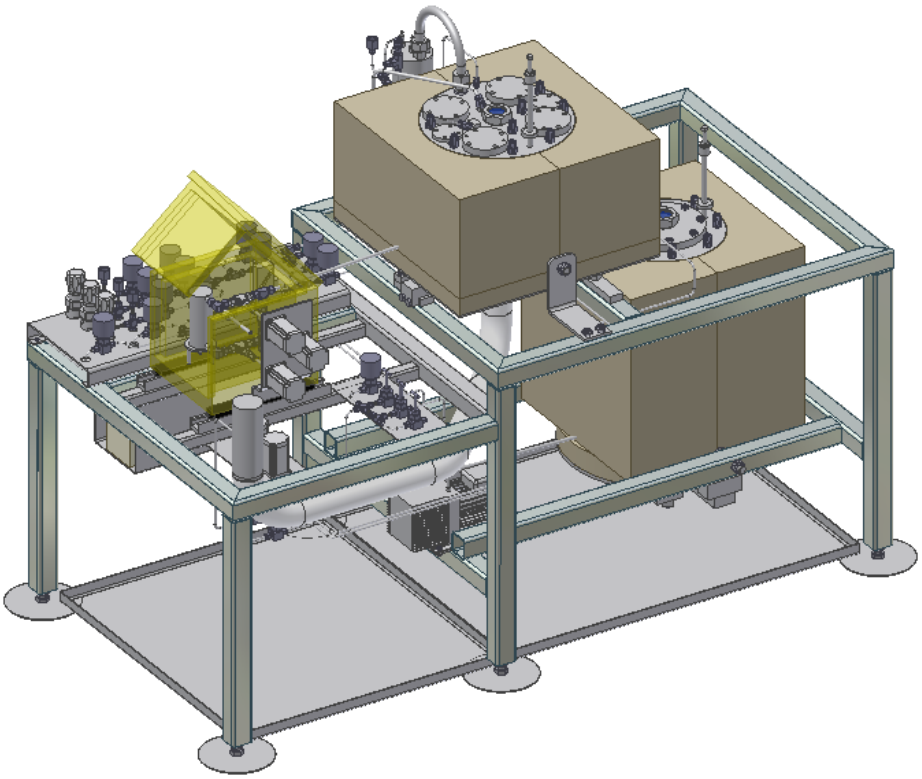

FIG. 2. View of the Heavy Liquid Metal Experimental Facility

Parameters table

Coolant inventory	Ca. 25 l of liquid lead or lead-bismuth eutectic
Power	Max. 18 kW
Test sections	
TS #1-4	*Characteristic dimensions* Round bar tension: 6 mm Compact tension, 0.5C(T): w = 25 mm Disc-shaped compact tension, DC(T) diameter: 27 mm Three- and four-point bending test: Charpy type SEN(B): 10 x 10 x 55 mm Segmented cone mandrel test: L = 10 mm, 8 segments Maximum displacement: 5 mm
	Static/dynamic experiment Semi-static
	Temperature range in the test section (Delta T) 380-650°C (lead)
	Operating pressure and design pressure Operating pressure: 0.2 MPa; design pressure: 0.5 MPa
	Flow range (mass, velocity, etc.) Max. few cm/s
Coolant chemistry measurement and	Active chemistry control: - measurements of oxygen content in HLM and in gas

control (active or not, measured parameters)	- measurements of hydrogen and humidity content in inlet gas - measurements of temperatures in HLM and in gas
Instrumentation	- Thermocouples and oxygen sensors in HLM - Thermocouples, oxygen sensors, hydrogen sensors, humidity sensors, and pressure transducers in gas - Weighting tensometric sensors for HLM level measurements

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

N/A – facility under design / construction

PLANNED EXPERIMENTS (including time schedule)

The facility is expected to start its first experimental campaign during 2016. Tensile, fracture toughness, and fatigue tests in lead will be performed, contributing to the establishment of test procedures, material databases, assessment procedures, and subsequently Design Rules for welded components in HLM-cooled nuclear reactors. The focus will be on reference structural materials considered for MYRRHA and ALFRED, i.e. relatively thick-walled welded components of 316L or 316L(N). With a support of modelling, the experimental data will also be used to describe the underlying degradation mechanisms.

TRAINING ACTIVITIES

After the facility is put into operation, training activities can be agreed with JRC Petten for the operation of an experimental campaign under the supervision of the JRC qualified staff. Open access policy will be adopted.

REFERENCES (*specification of availability and language*)

1. TUČEK K., FÜTTERER M., NOVOTNÝ R., TIMKE T., RIPPLINGER S., NILSSON K.-F., HÄHNER P., JRC-IET's Heavy Liquid Metal Experimental Facility – Technical Specifications, Technical Report (available in English), JRC92589, JRC Petten, 2014.